JPL

Frequently Asked Questions Regarding the Cassini Mission Earth Swingby

How can you reconcile NASA's claim that the RTGs "were designed to withstand re-entry" into our atmosphere (FEIS p. E94 et al.), with the statement in the SER that they were not designed to withstand the heat of an accidental re-entry at the planned flyby-by speed of 10 miles per second (p. 3-24)?

This quote is not from the June 1995, Final EIS (FEIS) but is from the 1996 Final Supplemental EIS (SEIS) and is taken out of context and falsely implies NASA claimed the RTG "containers" were designed to withstand re-entry during the Cassini Earth swingby. NASA never makes such a claim in any EIS. Page E-94 of the SEIS clearly states "The GPHS-RTGs modules and the Light Weight Radioisotope Heater Units (LWRHUs) were designed to withstand reentry from Earth orbit." In the preceding paragraph the SEIS explains that "The analysis differentiates between the orbital and VVEJGA (EGA swingby) reentry conditions." Though the RTG modules (or "containers") were designed to withstand re-entry from Earth orbit, NASA did not say or imply they were designed to withstand a re-entry during the Cassini Earth swingby.

Given the Cassini flyby will take place during the next big meteor shower, the Perseids, what is the chance Cassini could similarly be hit by a meteor and then crash into Earth?

The Cassini mission planners were aware of the Perseids meteor shower when designing the mission trajectory years before launch. An analysis was conducted on the possibility of Cassini being hit by a meteoroid of any size, large or tiny, including a hit from a Perseids meteoroid. The analysis showed that the probability of a meteoroid hit that would also throw Cassini off course in just the right way to make it hit Earth was less than one in one million. For further detail refer to the 1997 Cassini Supplemental Environmental Impact Statement (section 4.1.1.2) and the 1995 Cassini Environmental Impact Statement (section 4.1.5.2).

Additional Information

After a meteoroid enters the Earth's atmosphere it is referred to as a meteor.

What would happen if a meteor hit Cassini spacecraft and knocked out its communication system?

Loss of communication alone could not cause Cassini to impact the Earth. This is because loss of communication does not change the spacecraft's trajectory that is already safely pointed many thousands of miles away from Earth. It is important to note that most types of spacecraft or mission failures cannot change Cassini's trajectory, and only a tiny fraction of the possible trajectory changes could conceivably redirect the spacecraft into an Earth reentry.

Could Cassini be damaged by solar flares?

All Cassini hardware is designed, built, and tested against very stringent standards regarding radiation from solar flares, the galactic background radiation, and other sources (such as the trapped protons at Saturn and radiation at Jupiter). There is no way a flare can cause the Cassini spacecraft to go onto an Earth impacting trajectory.

Additional Information

Damage to the flight hardware is an extremely remote possibility. Single event upsets are a possibility but the on-board fault protection and ground operations are prepared to deal with them if necessary.

When and where will the Cassini spacecraft pass closest to Earth during the swingby?

The closest approach to Earth will be 3:28 AM GMT (Greenwich Mean Time) August 18, 1999 or 8:28 PM PDT August 17, 1999.

The closest approach point will be over the Eastern South Pacific. The spacecraft may be visible from small islands in that area, such as Pitcairn Island or Easter Island. The closest approach point is located at -23.5 latitude and 231.5 degrees longitude.

The spacecraft will not orbit the Earth, but it will fly past it. Since the spacecraft is not in an elliptical orbit bound to the Earth it is not possible to describe the ground track in the same manner as an Earth

orbiting spacecraft like the Shuttle. The altitude at closest approach will be about 1166 km (725 miles).

How can the probability of an Earth swingby reentry accident be so low?

- The Cassini mission has been designed to ensure than an inadvertent swingby accident does not occur. Mission rules state that the chance of such an accident occurring must be less than one in one million. JPL has conducted an in-depth analysis, which incorporated human error and historical JPL spacecraft data, to determine the probability of an inadvertent reentry. This analysis determined that the probability of an inadvertent Earth reentry is less than one in one million. This result may be surprising to some people (at first) since it is difficult to prove that failures of any system, particularly spacecraft, can be that small. The result is driven by two factors.
- First, for most of the Cassini trajectory it is very hard to hit the Earth. In fact, until about 50 days before Earth swingby, the probability of hitting the Earth is much less than one in one million regardless of the spacecraft failure (this is because of the vastness of space, the smallness of the Earth as a target, and the randomness of a spacecraft failure or micrometeoroid hit leading to a velocity change).
- Second, JPL has "biased" the trajectory for Earth swingby. This scheme further limits the time and events that could cause inadvertent reentry by eliminating all failures except those that give the spacecraft the proper velocity magnitude and direction to impact the Earth. The spacecraft is biased 5,000 kilometers (3,106 miles) or more away from the swingby altitude (not less than 500 km) for all but about 7 days prior to the swingby. The navigation accuracy of NASA spacecraft is better than 20 km. The biasing strategy effects, coupled with redundant spacecraft system design, built-in fault detection and correction systems, and controlled operation (via sending commands to the spacecraft), particularly during the limited time when failures could cause impact, lead to the exceedingly small probability of Earth impact.

What are the risk estimates of a swingby accident?

- The risk to the world population from a swingby reentry accident is very low.
- A series of tests and in-depth analyses were conducted to determine and validate design strategies and measures that reduce the probability of an inadvertent Earth swingby reentry accident to less than one in one million. This small probability, which has been validated by experts outside of NASA, is achieved by biasing the spacecraft trajectory away from the Earth. The biasing strategy effects, coupled with redundant spacecraft system design, built-in fault detection and correction systems, and the ability of ground-control to send signals to the spacecraft, lead to the exceedingly small probability of Earth impact.
- Even if you assume there is a swingby reentry accident, the radiation that an exposed person would be expected to receive over 50 years is thousands of times smaller than the radiation dose they will receive from natural background radiation such as radon and cosmic rays.
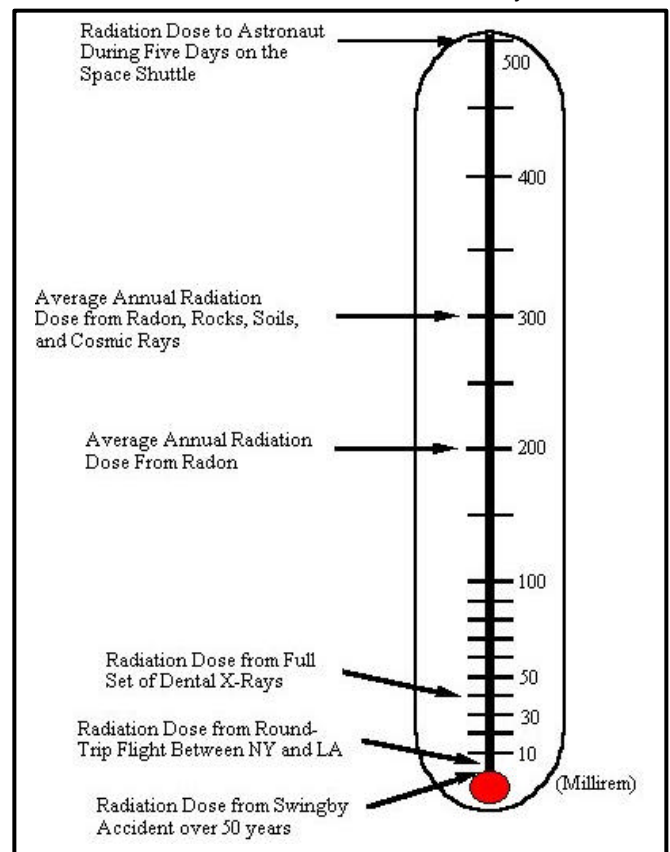
Isn't it true that the June 1995 Cassini EIS states that if "reentry occurred, approximately 5 billion of the estimated 7 to 8 billion world population...could receive 99 percent or more of the radiation exposure?

- That statement is taken out of context from the Cassini Environmental Impact Statement and can be difficult to understand. The statement refers to an unlikely 'one in one million chance' scenario where the Cassini spacecraft inad-vertently reenters the Earth's atmosphere after completing its swingby of the planet Venus.
- In this accident scenario, only a tiny fraction of the released plutonium would be breathed in or consumed and retained by humans.
- That small amount that would be taken in and retained by people would be distributed among approximately 5 billion people. Over a period of 50 years, individuals would take in less than one trillionth of a gram and on the average receive less than 1 millirem of radiation.
- Over the same period of time, individuals will be exposed to approximately 15,000 millirem from natural background radiation.

What is the current estimate for the Earth flyby altitude?

Before Cassini was launched, we reported that the swingby altitude would be at least 800 km (500 miles). That actual flyby altitude, however, depends on Cassini's launch date. Since Cassini was launched on October 15 (as opposed to the originally planned launch date of October 6) the actual swingby altitude will be about 1166 km (725 miles).

Shouldn't the public be concerned with the study done for the White House that said "several tens of thousands of latent cancer fatalities worldwide" could result from a Cassini flyby accident?

The statement attributed to the Interagency Nuclear Safety Review Panel's SER for the Cassini mission is taken out of context. The several tens of thou-sands of potential cancer fatalities relate to a hypo-thetical assumption of a complete burnup of the Cassini space vehicle and RTGs upon atmospheric reentry. The main point being made by this hypothe-tical case was to illustrate that while a linear non-threshold model can predict a large number of latent cancer fatalities, the average 50-year dose delivered to any individual would likely be on the order of 1 millirem (mrem). To place this hypothetical 50-year dose level in the proper perspective, it is equal to the average daily dose received by any individual from exposure to background natural and manmade sources of radiation. Based on the linear non-threshold dose response hypothesis, the average individual would be eighteen thousand (18,000) times more likely to contract a fatal cancer in 50 years from exposure to normal background levels of radiation than from the postulated hypothetical release and vaporization of the entire inventory of plutonium upon reentry. The SER provides an independent estimate of 1,500 latent cancer fatalities, but concurred that the probability of a Earth reentry and release is less than 1 in 1,000,000.

Do the conclusions of the NASA-cosponsored, National Academy of Sciences report, in April 1997 on low level radiation health effects mean that the health dangers of the dispersal of plutonium during an accidental swingby re-entry are much greater than calculated in the Cassini EIS?

The referenced work is by Hei, et al., and was published in the April 1997 issue of the Proceedings of the National Academy of Sciences. The conse-quence and risk analyses performed for the Cassini mission accord with this NAS study. Furthermore, the EIS and SEIS results reflect the internal dosimetry models presented in the International Commission on Radiological Protection (ICRP) Publication 30 and the radiation health effects estimator for the induction of fatal cancers as outlined in ICRP Publication 60, both of which are accepted by the national and international radiation protection community.